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(54) Acetylenic alcohols and ethers as accelerators for hydrosilation

Acetylenische Alkohole und Ethern als Beschleuniger für Hydrosilylierung

Alcools et éthers acétyléniques comme accélérateurs pour hydrosilylation

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(56) References cited:
EP-A- 0 510 957

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Description

The present invention is a hydrosilation process where a silicon hydride is reacted with an unsaturated reactant in the presence of a platinum catalyst and an accelerator selected from acetylenic alcohols, silated acetylenic alcohols and acetylenic ethers. The accelerators are especially useful for the hydrosilation of unsaturated reactants where the unsaturation is in the internal portion of the reactant's structure, for example, as in cyclopentene and cyclohexene and are effective in the presence or absence of oxygen.

It is known in the art to produce organosilicon compounds by reacting a silicon hydride containing compound with an unsaturated organic compound in the presence of a catalyst. This reaction is typically referred to as hydrosilation or hydrosilylation. Typically, the catalyst is platinum metal on a support, a platinum compound generally in a solvent or a platinum complex.

In U.S. Patent 2,823,218, a method for the production of organosilicon compounds by reacting an Si-H with a compound containing aliphatic carbon atoms linked by multiple bonds in the presence of chloroplatinic acid is taught. U.S. Patent 3,220,972, teaches a similar process, however, the catalyst is a reaction product of chloroplatinic acid.

One of the major problems known in the art with hydrosilation reactions is the deactivation of the catalyst prior to completion of the reaction. One method for reactivation of the catalyst has been to expose the reaction mixture to oxygen. For example, U.S. Patent 4,578,497, teaches the use of an oxygenated platinum containing catalyst for use in hydrosilating alkylsilanes. U.S. Patent 5,359,111, discloses a method for controlling hydrosilation reaction mixtures by controlling the solution concentration of oxygen in the reaction mixture, relative to the platinum present in the reaction mixture.

EP-A- 0 510 957 describes a hydrosilation method comprising reacting a silicon hydride with an olefinically unsaturated material in the presence of a platinum catalyst using cyclodextrin to enhance the rate of olefin addition.

In addition to the problem of deactivation of the platinum catalyst, hydrosilation processes taught in the art are not particularly effective in hydrosilating internal unsaturated bonds in organic molecules. We have unexpectedly found that acetylenic alcohols, silated acetylenic alcohols, and acetylenic ethers can act as accelerators for platinum catalyzed hydrosilation processes. The accelerators improve yield of the process in the presence or absence of oxygen and are particularly effective in facilitating the hydrosilation of internal unsaturated bonds of organic molecules.

The present invention is a hydrosilation process where a silicon hydride is reacted with an unsaturated reactant in the presence of a platinum catalyst and a novel accelerator. The hydrosilation process comprises contacting

(A) a silicon hydride described by formula $R^1_aH_bSiCl_{4-a-b}$ (1), where each R^1 is independently selected from alkyls comprising one to 20 carbon atoms, cycloalkyls comprising four to 12 carbon atoms and aryls; a=0 to 3, b=1 to 3, and a+b=1 to 4; and

(B) an unsaturated reactant selected from (i) unsaturated organic compounds, (ii) silicon compounds comprising unsaturated organic substituents, and (iii) mixtures of (i) and (ii);

in the presence of a platinum catalyst selected from platinum compounds or platinum complexes, and an accelerator selected from acetylenic alcohols described by formulae

$$R^2-(CR^6_2)_f-C\equiv C-\overset{R^3}{\underset{R^3}{\overset{|}{\underset{|}{C}}}}-OH \quad (2),$$

$$R^2-(CR^6_2)_f-C\equiv C-\overset{OH}{\overset{|}{C}}\underbrace{-(CH_2)_n-}_{} \quad (3),$$

$$-\left[C\equiv C-\overset{R^3}{\underset{R^3}{\overset{|}{\underset{|}{C}}}}-OH\right]_2 \quad (4),$$

$$-\left[C{\equiv}C-\overset{OH}{\overset{|}{C}}-(CH_2)_n\right]_2 \quad (5),$$

silated acetylenic alcohols described by formulae

$$\left[R^2-(CR^6{}_2)_f-C{\equiv}C-\underset{R^3}{\overset{R^3}{C}}-O\right]_e SiR^4{}_cH_dCl_{4-c-d-e} \quad (6),$$

$$-\left[C{\equiv}C-\underset{R^3}{\overset{R^3}{C}}-OSiR^4{}_cH_dCl_{3-c-d}\right]_2 \quad (7),$$

acetylenic ethers described by formulae

$$R^2-(R^6{}_2)_f-C{\equiv}C-\underset{R^3}{\overset{R^3}{C}}-OR^5 \quad (8)$$

and

$$-\left[C{\equiv}C-\underset{R^3}{\overset{R^3}{C}}-OR^5\right]_2 \quad (9)$$

where R^2 is selected from hydrogen, hydroxyl, substituted and unsubstituted alkyls comprising one to 20 carbon atoms, and substituted and unsubstituted alkoxys comprising one to 20 carbon atoms, each R^3 is independently selected from hydrogen, alkyls comprising one to 20 carbon atoms, cycloalkyls comprising four to 20 carbon atoms, and aryls; each R^4 is an independently selected alkyl or cycloalkyl comprising no more than 20 carbon atoms, R^5 is selected from monovalent hydrocarbon radicals comprising one to 20 carbon atoms and heterocyclic hydrocarbon radicals having a carbon to oxygen bond, each R^6 is independently selected from hydrogen and R^1, c=0 to 3, d=0 to 3, c+d=0 to 3, e=1 to 4, f=0 to 10, and n=4 to 12.

The contacting of the silicon hydride with the unsaturated reactant is effected in standard type reactors for conducting hydrosilation processes. The contact and reaction may be run as a continuous, semi-continuous, or batch reaction.

Silicon hydrides which are useful in the present process are described by formula (1), where each R^1 is independently selected from alkyls comprising one to 20 carbon atoms, cycloalkyls comprising four to 12 carbon atoms, and aryls; a=0 to 3, b=1 to 3, and a+b=1 to 4. R^1 is a substituted or unsubstituted alkyl, cycloalkyl or aryl as described.

In formula (1) it is preferred that each R^1 be independently selected from alkyls comprising one to six carbon atoms.

Even more preferred is when each R^1 is methyl. Examples, of silicon hydrides described by formula (1) which are useful in the present process include trimethylsilane, dimethylsilane, triethylsilane, dichlorosilane, trichlorosilane, methyldichlorosilane, dimethylchlorosilane, ethyldichlorosilane, cyclopentyldichlorosilane, methylphenylchlorosilane and (3,3,3-trifluoropropyl)dichlorosilane. Examples of preferred silicon hydrides described by formula (1) include methyldichlorosilane and dichlorosilane.

The silicon hydride is contacted with an unsaturated reactant selected from a group consisting of (i) unsaturated organic compounds, (ii) silicon compounds comprising unsaturated organic substituents and (iii) mixtures of (i) and (ii). For purposes of this invention, "unsaturated" means that the compound contains at least one carbon-carbon double bond.

Specific examples of the unsaturated reactants useful in the present process include unsubstituted cycloalkene compounds comprising at least four carbon atoms, substituted cycloalkene compounds comprising at least four carbon atoms, linear alkene compounds comprising two to 30 carbon atoms, branched alkene compounds comprising four to 30 carbon atoms, and mixtures of two or more of any of the above.

Possible substituents of the unsaturated organic compounds or of the silicon compounds comprising the unsaturated organic substituents include alkyl groups, such as C_{1-4} alkyl groups, aryl groups, particularly phenyl, halogen such as chlorine, fluorine and bromine, oxygen in the form of acids, anhydrides, alcohols, esters and ethers, and nitrogen.

The substituted and unsubstituted cycloalkene compounds useful in the present process are those containing one or more unsaturated carbon-carbon bonds in the ring. The unsubstituted cycloalkene compounds may be cyclobutene, cyclopentene, cyclohexene, cycloheptene, cyclooctene, cyclopentadiene, 1,3-cyclohexadiene and 1,3,5-cycloheptatriene. Substituted unsaturated compounds useful in the invention may be 3-methylcyclopentene, 3-chlorocyclobutene, 4-phenylcyclohexene and 3-methylcyclopentadiene. The preferred cycloalkene compounds are cyclohexene and cyclopentene, with cyclohexene being the most preferred.

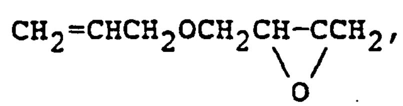
Other unsaturated organic compounds useful in the present process are linear and branched alkenyl compounds including, for example, compounds with terminal unsaturation such as 1-hexene and 1,5-hexadiene, compounds with internal unsaturation such as trans-2-hexene and unsaturated aryl containing compounds such as styrene and α-methylstyrene.

The unsaturated reactants may also comprise halogen, oxygen in the form of acids, anhydrides, alcohols, esters and ethers; and nitrogen. Two or more of the above described unsaturated organic compounds may be used in the present process.

The unsaturated organic compounds comprising halogen include vinyl chloride, allyl chloride, allyl bromide, allyl iodide, allyl bromide, methallyl chloride, trichloroethylene, tetrachloroethylene, tetrafluoroethylene, chloroprene, vinylidene chloride and dichlorostyrene.

Suitable unsaturated organic compounds comprising oxygen include ethers such as allyl and vinyl ethers; alcohols such as allyl alcohol (vinyl carbinol), methylvinylcarbinol and ethynyldimethyl-carbinol; acids such as acrylic, methacrylic, vinylacetic, oleic, sorbic and linolenic; and esters such as vinyl acetate, allyl acetate, butenyl acetate, allyl stearate, methylacrylate, ethylcrotonate, dially succinate and dially phthalate. Suitable nitrogen containing unsaturated organic compounds include, for example, indigo, indole, acrylonitrile and allyl cyanide.

Specifically included within the definition of unsaturated organic compounds are those substituted by organofunctional moieties such as $CH_2=CHCH_2OC(O)C(CH_3)=CH_2$, $CH_2=CHCH_2NHCH_2CH_2NH_2$, $CH_2=CHCH_2NH_2$,



$CH_2=CHCH_2SH$, $CH_2=CHSi\{O(CH_2)_2OCH_3\}_3$, $CH_2=CHCH_2N(HCl)HCH_2CH_2NHCH_2(C_6H_4)CH=CH_2$, and similar such compounds.

The unsaturated organic compound is a silicon compound comprising substituted or unsubstituted organic substituents as described by, for example, formulae $(CH_2=CH(CH_2)_g)_hR^1{}_iSi(OR^1)_{4-h-i}$ and $(CH_2=CH(CH_2)_g)_hR^1{}_iSi\text{-}Cl_{4-h-i}$, where R^1 is as previously described, g=0 to 12, h=1 Cl_{4-h-i}, where R^1 is as previously described, g=0 to 12, h=1 to 3, i=0 to 3 and h+i=1 to 4.

Prior to contact of the silicon hydride with the unsaturated reactant, it may be preferable to treat or purify the unsaturated reactant. Methods useful for treating or purifying the reactants are those known in the art for treating or purifying unsaturated organic compounds, and include, but are not limited to, distillation or treatment with an adsorbent such as activated alumina or molecular sieves.

The relative amounts of silicon hydride and unsaturated reactant used in the present process is varied within wide limits. Although one unsaturated carbon-carbon linkage per silicon bonded hydrogen atom is stoichiometric, there is

no requirement that the process be run under stoichiometric conditions. Generally, it is preferred that the process be run with a stoichiometric excess of silicon hydride. Preferred is when the process is run with 0.1 to ten percent stoichiometric excess of silicon hydride. However, in some situations for safety reasons, it is preferred to run the process with an excess of unsaturated reactant, for example when the silicon hydride is dichlorosilane.

The silicon hydride and unsaturated reactant are contacted in the presence of a platinum catalyst selected from platinum compounds or platinum complexes. Any platinum containing material, which effects the reaction between the silicon hydride and an unsaturated carbon-carbon bond of the unsaturated organic compound, is useful in the present invention. Examples of useful platinum catalysts in the present process are described in U.S. Patents 4,578,497; 3,220,972 and 2,823,218.

The platinum catalyst is chloroplatinic acid, chloroplatinic acid hexahydrate, Karstedt's catalyst (i.e. a complex of chloroplatinic acid with sym-divinyltetramethyldisiloxane), dichlorobis(triphenylphosphine)platinum(II), cis-dichlorobis (acetonitrile)platinum(II), dicarbonyldichloroplatinum(II), platinum chloride and platinum oxide.

A preferred platinum catalyst is selected from the group consisting of chloroplatinic acid, chloroplatinic acid hexahydrate, and platinum vinylsiloxane complexes such as a neutralized complex of chloroplatinic acid or platinum dichloride with sym-divinyltetramethyldisiloxane.

Generally, those concentrations of platinum catalyst which provide one mole of platinum metal per billion moles of unsaturated carbon-carbon bonds added to the process by the unsaturated reactant are useful in the present process. A preferred concentration of platinum catalyst is that providing one to 1000 moles of platinum metal per 1 X 10^6 moles of unsaturated carbon-carbon bonds provided to the process by the unsaturated reactant. Concentrations of platinum catalyst providing as high as one mole of platinum metal per one thousand moles of unsaturated carbon-carbon bonds added to the process by the unsaturated reactant are highly preferred. Higher concentrations of platinum may be used if desired.

The platinum catalyst may be dissolved in a solvent for ease of handling and to facilitate measuring the small amounts typically needed. Suitable solvents include non-polar hydrocarbon solvents such as benzene, toluene, and xylene and polar solvents such as alcohols, ketones, glycols and esters.

The present process is carried out in the presence of an accelerator selected from a group as described above by formulas (2) through (9). The substituent R^2 is selected from a group consisting of hydrogen, hydroxyl, substituted and unsubstituted alkyls comprising one to 20 carbon atoms, and substituted and unsubstituted alkoxys comprising one to 20 carbon atoms. Preferred is when R^2 is selected from hydrogen or alkyls comprising one to six carbon atoms. Substituent R^2 can be a substituted alkyl, for example, hydroxyethyl, 2-ethoxyethyl and 1-methyl-1-hydroxyethyl. R^2 can also be hydrogen, methyl, ethyl, propyl, iso-butyl, hydroxyethyl, 1-methyl-1-hydroxyethyl, and hexyl. Preferred is when R^2 is hydrogen. Each substituent R^3 is independently selected from a group consisting of hydrogen, alkyls comprising one to 20 carbon atoms, cycloalkyls comprising four to 20 carbon atoms, and aryls. R^3 can be, for example, hydrogen, methyl, ethyl, propyl, iso-butyl, cyclopentyl, cyclohexyl and phenyl. Preferred is when each R^3 is independently selected from a group consisting of hydrogen, alkyls comprising one to 6 carbon atoms, and phenyl. Each substituent R^4 is an independently selected alkyl or cycloalkyl comprising no more than 20 carbon atoms. Preferred is when R^4 is selected from methyl or cyclopentyl. R^5 is selected from monovalent hydrocarbon radicals comprising one to 20 carbon atoms or heterocyclic hydrocarbon radicals having a carbon to oxygen bond. R^5 can be, for example, alkyls such as methyl, ethyl, tert-butyl; cycloalkyls such as cyclopentyl or cyclohexyl; aryls such as phenyl or naphthyl; and heterocyclic hydrocarbons such as tetrahydrofuranyl. Each substituent R^6 is independently selected from hydrogen or R^1 as previously described. Preferred is when R^6 is hydrogen.

In the silated acetylenic alcohols described by formulas (6) and (7), c has a value of zero to three, d has a value of zero to three, and c plus d has a value of zero to three. In formula (6), e has a value of one to four. Preferred is when e has a value of one.

In the acetylenic alcohols described by formulas (3) and (5), n has a value of four to 12. Preferred is when n has a value of four or five.

In the acetylenic alcohols described by formulas (2), (3), (6) and (8), f has a value of zero to ten. Preferred is when f is a value of zero to four.

A preferred accelerator for use in the present process is selected from a group consisting of 2-methyl-3-butyn-2-ol, silated 2-methyl-3-butyn-2-ol, 1-ethynyl-1-cyclohexanol and 3,5-dimethyl-1-hexyn-3-ol.

An effective concentration of the accelerator is added to the present process, where an effective concentration is one that facilitates initiation of the reaction between the silicon hydride and the unsaturated organic compound, accelerates the rate of the reaction, or reduces loss of reactivity of the catalyst in the process. A useful effective concentration of accelerator is generally within a range of 0.01 to 20 weight percent of the weight of the unsaturated reactant. Preferred is when the accelerator is 0.1 to ten weight percent of the unsaturated reactant. The accelerator may be added to the process as a pre-mix with the platinum catalyst or separately.

The temperature at which the present process is conducted is generally within a range of -10°C. to 220°C. It is preferred to conduct the process at a temperature within a range of 15°C. to 170°C. The most preferred temperature

for conducting the process is within a range of 30°C. to 150°C.

Example 1

A variety of acetylenic alcohols, silated alcohols and acetylenic ethers were evaluated for their ability to accelerate the reaction of methyldichlorosilane with cyclohexene in the presence of a platinum catalyst.

A stock mixture was prepared in an argon purged and blanketed bottle. The stock mixture comprised four molar percent excess of methyldichlorosilane in cyclohexene which had been treated with 13X molecular sieves. Next, 6 x 10^{-5} moles of platinum, as a platinum divinylsiloxane complex, per mole of cyclohexene was added to the stock mixture. Aliquots of this catalyzed stock solution were then transferred to argon-purged glass tubes which contained accelerators of the structures provided in Table 1 at a concentration of 1 weight percent of the cyclohexene added to the tube. The tubes were heat sealed under argon purge and heated at 80°C. for three hours. At the end of three hours, the tubes were cooled and the contents analyzed by gas chromatography using a thermal conductivity detector (GC-TC). The results of this analysis are reported in Tables 1 and 2 as the normalized area percent of methyl(cyclohexyl)dichlorosilane (MeC_HSiCl_2) under the GC-TC trace. The data was normalized by using the area under the GC-TC trace minus the area of the cyclohexene as 100 percent. In the Tables, the heading "Formula Type" refers to the formulas as numbered in the specification.

Table 1

Acetylenic Alcohols and Ethers as Accelerators For Platinum Catalyzed Addition of $MeHSiCl_2$ to Cyclohexene							
Type	Formula Type	Structure					Area%
		R^2	R^3	R^3	R^5	n	
Alcohol	(2)	H	H	H	-	-	87.2
	(2)	H	H	Me	-	-	98.5
	(2)	Et	H	H	-	-	94.9
	(2)	H	H	Ph	-	-	85.8
	(2)	H	Me	Me	-	-	98.4
	(2)	H	Me	i-bu	-	-	99.7
	(2)	HO-Et	Me	Me	-	-	98.5
	(4)	-	Me	Me	-	-	95.4
	(3)	H	-	-	-	5	99.5
	(3)	Me	-	-	-	5	70.9
	(3)	Et	-	-	-	4	86.5
	(5)	-	-	-	-	5	70.2
Ether	(8)	H	Me	Me	THF	-	84.7
Blank	(Ave. n=5)	-	-	-	-	-	35.6

Table 2

Silated Acetylenic Alcohol Accelerators for Platinum Catalyzed Addition of $MeHSiCl_2$ to Cyclohexene							
Formula Type	Structure						Area(%)
	R^2	R^3	R^3	R^4	c	d	
(6)	H	Me	Me	Me	3	0	98.2
	H	Me	Me	-	0	1	8.4
	H	Me	Me	-	0	0	51.3

In Tables 1 and 2, Me is methyl, Et is ethyl, Ph is phenyl, i-bu is isobutyl, HO-Et is 1-methyl-1-hydroxyethyl and THF is tetrahydrofuranyl.

Example 2

The ability of 2-methyl-3-butyn-2-ol (MBO) to accelerate the reaction of dichlorosilane with cyclopentene in the presence of a platinum catalyst was evaluated.

A stock mixture was prepared in an argon purged and blanketed bottle. The stock mixture comprised 11.2 weight percent of dichlorosilane in cyclopentene. A platinum divinylsiloxane complex providing a final concentration of platinum, based on dichlorosilane, as described in Table 3 (Pt ppm) was added to the stock mixture. Aliquots of this catalyzed stock solution were then transferred to argon-purged glass tubes and MBO was added at the concentrations described in Table 3. The concentration of MBO (%MBO) is given as a weight percent of the total weight of the mixture. The tubes were then heat sealed under argon purge and heated for the times and temperatures described in Table 3. At the end of the heating period the tubes were cooled to room temperature and the contents analyzed by GC-TC. The results of this analysis are also reported in Table 3 as the area percent under the GC-TC trace for each addition product.

Table 3

2-Methyl-3-butyn-2-ol as Accelerator For Platinum Catalyzed Addition of H_2SiCl_2 to Cyclopentene

Pt (ppm)	%MBO	T(min.)	°C	Area %				
				CpH_2SiCl	$CpHSiCl_2$	$CpSiCl_3$	Cp_2HSiCl	Cp_2SiCl_2
200	0.1	120	120	0.64	5.30	0.50	0.00	0.20
200	1.0	60	120	0.00	11.30	0.50	0.00	0.00
1000	0.5	30	120	0.27	12.60	0.60	0.10	0.60
1000	0.5	60	120	0.70	9.30	0.50	0.10	0.30
1000	0.5	120	120	0.59	11.20	0.60	0.20	0.16
1000	1.0	60	120	0.00	0.00	0.00	0.00	11.50
2000	0.0	10	24	0.00	1.95	0.00	1.60	0.00
2000	1.0	10	24	0.00	13.80	0.60	0.00	0.00
2000	1.0	960	24	0.16	12.90	0.60	0.16	4.10
2000	1.0	15	120	0.00	1.79	1.30	0.45	13.00
2000	1.0	30	120	0.16	1.39	0.90	0.50	15.80

In Table 3, Cp is cyclopentyl.

Example 3

The ability of 2-methyl-3-butyn-2-ol (MBO) to accelerate the reaction of methyldichlorosilane with cyclooctene was evaluated.

A stock mixture was prepared in an argon purged and blanketed bottle. The stock mixture comprised 52 weight percent methyldichlorosilane in cyclooctene which had been treated with 13X molecular seives. A platinum divinylsiloxane complex was added to the stock mixture to provide a platinum concentration of about 58 ppm in the stock mixture. Aliquots of this catalyzed stock mixture were then transferred to argon-purged glass tubes and MBO was added to provide a concentration of 1 weight percent of the total weight of the mixture. The tubes were then heat sealed under argon purge and heated at 120°C. for the times sealed under argon purge and heated at 120°C. for the times reported in Table 4. At the end of the heating period, the tubes were cooled to about room temperature and the contents analyzed by GC-TC. The results of this analysis areare reported in Table 4 as the area percent under the GC-TC trace for cyclohexylmethyldi-chlorosilane.

Table 4

2-Methyl-3-butyn-2-ol as Accelerator For Platinum Catalyzed Addition of MeHSiCl2 to Cyclooctene

Time (h)	$MeC_8H_{15}SiCl_2$ (Area%)
3.0	8.9
5.5	13.4
22.0	16.6

Table 4 (continued)

2-Methyl-3-butyn-2-ol as Accelerator For Platinum Catalyzed Addition of MeHSiCl2 to Cyclooctene	
Time (h)	$MeC_8H_{15}SiCl_2$ (Area%)
5.5*	2.7

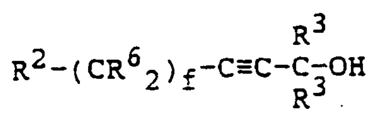
*Control-no accelerator added.

Claims

1. A hydrosilation process comprising contacting

(A) a silicon hydride described by formula $R^1{}_aH_bSiCl_{4-a-b}$ where each R^1 is independently selected from alkyls comprising one to 20 carbon atoms, cycloalkyls comprising four to 12 carbon atoms, and aryls; a=0 to 3, b=1 to 3, and a+b=1 to 4; and
(B) an unsaturated reactant selected from (i) unsaturated organic compounds, (ii) silicon compounds comprising unsaturated organic substituents, and (iii) mixtures of (i) and (ii);

in the presence of a platinum catalyst selected from platinum compounds or platinum complexes, and an accelerator selected from acetylenic alcohols described bv formulae



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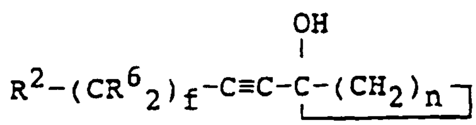

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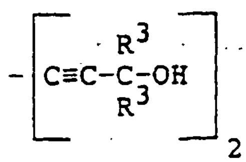

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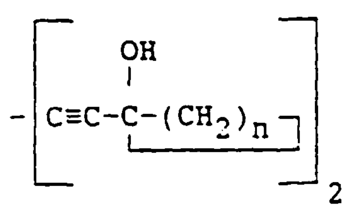

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silated acetylenic alcohols described by formulae

$$\left[R^2-(CR^6{}_2)_f-C\equiv C-\underset{R^3}{\overset{R^3}{C}}-O\right]_e SiR^4{}_cH_dCl_{4-c-d-e}$$

or

$$-\left[C\equiv C-\underset{R^3}{\overset{R^3}{C}}-OSiR^4{}_cH_dCl_{3-c-d}\right]_2 \quad ;$$

and acetylenic ethers described by formulae

$$R^2-(CR^6{}_2)_f-C\equiv C-\underset{R^3}{\overset{R^3}{C}}-OR^5$$

or

$$-\left[C\equiv C-\underset{R^3}{\overset{R^3}{C}}-OR^5\right]_2 \quad ;$$

where R^2 is selected from hydrogen, hydroxyl, substituted and unsubstituted alkyls comprising one to 20 carbon atoms, and substituted or unsubstituted alkoxys comprising one to 20 carbon atoms; each R^3 is independently selected from hydrogen, alkyls comprising one to 20 carbon atoms, cycloalkyls comprising four to 20 carbon atoms, and aryls; each R^4 is an independently selected alkyl or cycloalkyl comprising no more than 20 carbon atoms; R^5 is a monovalent hydrocarbon radical comprising one to 20 carbon atoms or a heterocyclic hydrocarbon radical having a carbon to oxygen bond and each R6 is independently selected from hydrogen and R^1, c=0 to 3, d=0 to 3, c+d=0 to 3, e=1 to 4, f=0 to 10 and n=4 to 12.

2. A process according to claim 1 where the silicon hydride is selected from trimethylsilane, dimethylsilane, triethylsilane, dichlorosilane, trichlorosilane, methyldichlorosilane, dimethylchlorosilane, ethyldichlorosilane, cyclopentyldichlorosilane, methylphenylchlorosilane and (3,3,3-trifluoropropyl)dichlorosilane.

3. A process according to claim 1 where the unsaturated reactant is selected from unsubstituted cycloalkene compounds comprising at least four carbon atoms, substituted cycloalkene compounds comprising at least four carbon atoms, linear alkene compounds comprising two to 30 carbon atoms, and branched alkene compounds comprising four to 30 carbon atoms.

4. A process according to claim 1 where the process is run with 0.1 to ten percent stoichiometric excess of silicon hydride relative to unsaturated carbon-carbon linkages of the unsaturated reactant.

5. A process according to claim 1 where the platinum catalyst is selected from chloroplatinic acid, chloroplatinic acid hexahydrate and platinum divinylsiloxane complexes.

6. A process according to claim 1 where substituent R^2 of the accelerator is selected from hydrogen and alkyls comprising one to six carbon atoms.

7. A process according to claim 1 where each substituent R^3 of the accelerator is independently selected from hydrogen, alkyls comprising one to six carbon atoms and phenyl.

8. A process according to claim 1 where substituent R^4 of the accelerator is selected from methyl and cyclopentyl.

9. A process according to claim 1 where substituent R^5 of the accelerator is selected from methyl, ethyl, tert-butyl, cyclopentyl, cyclohexyl, phenyl, naphthyl and tetrahydrofuranyl.

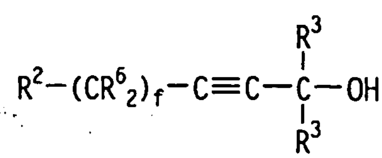
10. A process according to claim 1 where the concentration of the accelerator is within a range of 0.01 to 20 weight percent on the weight of the unsaturated reactant.

11. A process according to claim 1 where the process is conducted at a temperature within a range of -10°C. to 220°C.

Patentansprüche

1. Hydrosilylierungsprozeß umfassend Inkontaktbringen

(A) eines Siliciumhydrids, beschrieben durch die Formel $R^1{}_aH_bSiCl_{4-a-b}$, worin jedes R^1 unabhängig ausgewählt ist aus Alkylgruppen mit 1 - 20 Kohlenstoffatomen, Cycloalkylgruppen mit 4 - 12 Kohlenstoffatomen und Arylgruppen, a gleich 0 bis 3, b gleich 1 bis 3 ist, und a+b gleich 1 bis 4 ist und
(B) eines ungesättigten Reaktanten, ausgewählt aus (i) ungesättigten organischen Verbindungen, (ii) Siliciumverbindungen mit ungesättigten organischen Substituenten und (iii) Mischungen aus (i) und (ii) in der Gegenwart eines Platinkatalysators, ausgewählt aus Platinverbindungen oder Platinkomplexen und einem Beschleuniger, ausgewählt aus acetylenischen Alkoholen, beschrieben durch die Formeln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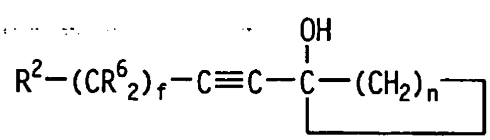
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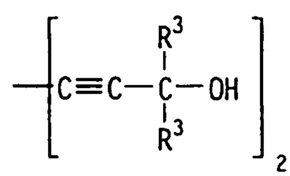
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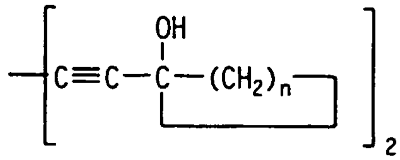
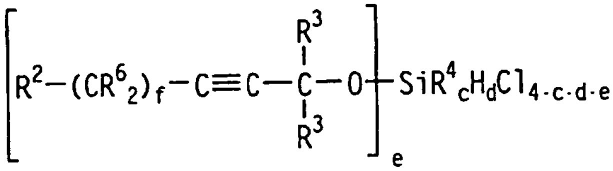
 ;

silylierten acetylenischen Alkoholen beschrieben durch die Formeln



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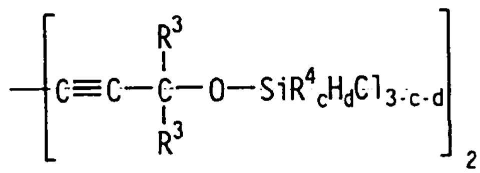
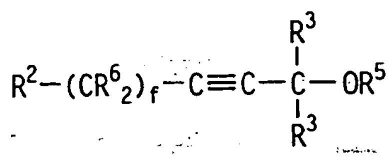
 ;

und und acetylenischen Ethern beschrieben durch die Formeln,



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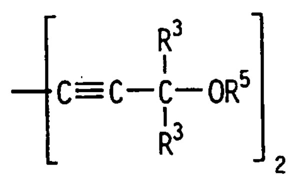
 ;

worin R^2 ausgewählt ist aus Wasserstoff, Hydroxyl, substituierten und unsubstituierten Alkylgruppen mit 1 - 20 Kohlenstoffatomen, und substituierten oder unsubstituierten Alkoxygruppen mit 1 - 20 Kohlenstoffatomen, jedes R^3 unabhängig voneinander ausgewählt ist aus Wasserstoff, Alkylgruppen mit 1 - 20 Kohlenstoffatomen. Cycloalkylgruppen mit 4 - 20 Kohlenstoffatomen und Arylgruppen, jedes R^4 ein unabhängig ausgewähltes Alkyl oder Cycloalkyl mit nicht mehr als 20 Kohlenstoffatomen ist, R^5 ein monovalenter Kohlenwasserstoffrest mit 1 - 20 Kohlenstoffatomen oder ein heterocyclischer Kohlenwasserstoffrest mit einer Kohlenstoff-Sauerstoffbindung ist und jedes R^6 unabhängig ausgewählt ist aus Wasserstoff und R^1, c gleich 0 bis 3 ist, d gleich 0 bis 3 ist, c+d gleich 0 bis 3 ist, e gleich 1 bis 4 ist, f gleich 0 bis 10 ist und n gleich 4 bis 12 ist.

2. Verfahren nach Anspruch 1, wobei das Siliciumhydrid ausgewählt ist aus Trimethylsilan, Dimethylsilan, Triethyl-

silan, Dichlorsilan, Trichlorsilan, Methyldichlorsilan, Dimethylchlorsilan, Ethyldichlorsilan, Cyclopentyldichlorsilan, Methylphenylchlorsilan und (3,3,3-Trifluorpropyl)dichlorsilan.

3. Verfahren nach Anspruch 1, wobei der ungesättigte Reaktant ausgewählt ist aus unsubstituierten Cycloalkenverbindungen mit mindestens vier Kohlenstoffatomen, substituierten Cycloalkenverbindungen mit mindestens vier Kohlenstoffatomen, linearen Alkenverbindungen mit zwei bis 30 Kohlenstoffatomen und verzweigten Alkenverbindungen mit vier bis 30 Kohlenstoffatomen.

4. Verfahren nach Anspruch 1, wobei das Verfahren mit einem 0,1 bis 10% stöchiometrischen Überschuß von Siliciumhydrid im Bezug auf ungesättigte Kohlenstoff-Kohlenstoff-Verknüpfungen des ungesättigten Reaktanten durchgeführt wird.

5. Verfahren nach Anspruch 1, wobei der Platinkatalysator ausgewählt ist aus Chloroplatinsäure, Chloroplatinsäurehexahydrat und Platindivinylsiloxankomplexen.

6. Verfahren nach Anspruch 1, wobei Substituent R^2 des Beschleunigers ausgewählt ist aus Wasserstoff und Alkylgruppen mit ein bis sechs Kohlenstoffatomen.

7. Verfahren nach Anspruch 1, worin jeder Substituent R^3 des Beschleunigers unabhängig ausgewählt ist aus Wasserstoff, Alkylgruppen mit ein bis sechs Kohlenstoffatomen und Phenyl.

8. Verfahren nach Anspruch 1, worin Substituent R^4 des Beschleunigers ausgewählt ist aus Methyl und Cyclopentyl.

9. Verfahren nach Anspruch 1, wobei Substituent R^5 des Beschleunigers ausgewählt ist aus Methyl, Ethyl, t-Butyl, Cyclopentyl, Cyclohexyl, Phenyl, Naphthyl und Tetrahydrofuranyl.

10. Verfahren nach Anspruch 1, wobei die Konzentration des Beschleunigers im Bereich von 0,01 bis 20 Gewichtsprozent bezogen auf das Gewicht des ungesättigten Reaktanten beträgt.

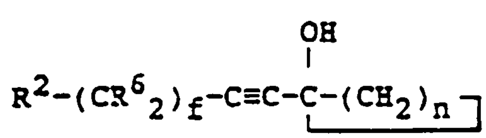
11. Verfahren nach Anspruch 1, wobei das Verfahren bei einer Temperatur im Bereich von -10°C bis 220°C durchgeführt wird.

Revendications

1. Procédé d'hydrosilylation consistant à mettre en contact

(A) un hydrure de silicium ayant la formule $R^1{}_aH_bSiCl_{4-a-b}$ dans lequel chaque R^1 est choisi indépendamment parmi les groupes alkyles comprenant un à 20 atomes de carbone, les groupes cycloalkyles comprenant quatre à 12 atomes de carbone, et les groupes aryles; a=0 à 3, b=1 à 3, et a+b=1 à 4; et
(B) un réactif insaturé choisi parmi (i) les composés organiques insaturés, (ii) les composés du silicium comprenant des substituants organiques insaturés et (iii) les mélanges de (i) et de (ii); en présence d'un catalyseur au platine choisi parmi les composés du platine ou les complexes du platine, et un accélérateur choisi parmi les alcools acétyléniques ayant les formules

$$R^2-(CR^6{}_2)_f-C{\equiv}C-\underset{R^3}{\overset{R^3}{\underset{|}{\overset{|}{C}}}}-OH \quad ,$$

 ,

$$-\left[C\equiv C-\underset{R^3}{\overset{R^3}{C}}-OH\right]_2 \quad ,$$

et

$$-\left[C\equiv C-\overset{\displaystyle OH}{\overset{|}{C}}-(CH_2)_n\right]_2 \quad ;$$

les alcools acétyléniques silylés ayant les formules

$$\left[R^2-(CR^6{}_2)_f-C\equiv C-\underset{R^3}{\overset{R^3}{C}}-O\right]_e SiR^4{}_cH_dCl_{4-c-d-e}$$

ou

$$-\left[C\equiv C-\underset{R^3}{\overset{R^3}{C}}-OSiR^4{}_cH_dCl_{3-c-d}\right]_2 \quad ;$$

et les éthers acétyléniques ayant les formules

$$-\left[C\equiv C-\underset{R^3}{\overset{R^3}{C}}-OR^5\right]_2 \quad ;$$

dans lesquelles R^2 est choisi parmi un atome d'hydrogène, le groupe hydroxyle, les groupes alkyles substitués et non substitués comprenant un à 20 atomes de carbone, et les groupes alcoxy substitués et non substitués comprenant un à 20 atomes de carbone; chaque R^3 est choisi indépendamment parmi un atome d'hydrogène, les groupes alkyles comprenant un à 20 atomes de carbone, cycloalkyles comprenant quatre à 20 atomes de carbone, et aryles; chaque R^4 est choisi indépendamment parmi un groupe aryle ou cycloalkyle ne comprenant pas plus de 20 atomes de carbone; R^5 est un radical hydrocarboné monovalent comprenant un à 20 atomes de carbone ou un radical hydrocarboné hétérocyclique possédant une liaison carbone-oxygène et chaque R^6 est choisi indépendamment parmi un atome d'hydrogène et R^1, c=0 à 3, d=0 à 3, c+d=0 à 3, e=1 à 4, f=0 à 10 et n=4 à 12.

2. Procédé selon la revendication 1, dans lequel l'hydrure de silicium est choisie parmi le triméthylsilane, le diméthylsilane, le triéthylsilane, le dichlorosilane, le trichlorosilane, le méthyldichlorosilane, le diméthyl-chlorosilane, l'éthyldichlorosilane, le cyclopentyl-dichlorosilane, le méthylphénylchlorosilane et le (3,3,3-trifluoropropyl)dichlorosilane.

3. Procédé selon la revendication 1, dans lequel le réactif insaturé est choisi parmi les composés cycloalcènes non substitués comprenant au moins quatre atomes de carbone, les composés cycloalcènes substitués comprenant au moins quatre atomes de carbone, les composés alcènes linéaires comprenant deux à 30 atomes de carbone, et les composés alcènes ramifiés comprenant quatre à 30 atomes de carbone.

4. Procédé selon la revendication 1, dans lequel le procédé est réalisé avec un excès de 0,1 à 10 pourcent par rapport à la quantité stoechiométrique d'hydrure de silicium par rapport aux liaisons carbone-carbone insaturées du réactif insaturé.

5. Procédé selon la revendication 1, dans lequel le catalyseur au platine est choisi parmi l'acide chloroplatinique, l'hexahydrate de l'acide chloroplatinique et les complexes divinylsiloxane platine.

6. Procédé selon la revendication 1, dans lequel le substituant R^2 de l'accélérateur est choisi parmi un atome d'hydrogène et les groupes alkyles comprenant un à six atomes de carbone.

7. Procédé selon la revendication 1, dans lequel chaque substituant R^3 de l'accélérateur est choisi indépendamment parmi un atome d'hydrogène, les groupes alkyles comprenant un à six atomes de carbone et le groupe phényle.

8. Procédé selon la revendication 1, dans lequel le substituant R^4 de l'accélérateur est choisi parmi les groupes méthyle et cyclopentyle.

9. Procédé selon la revendication 1, dans lequel le substituant R^5 de l'accélérateur est choisi parmi les groupes méthyle, éthyle, tert-butyle, cyclopentyle, cyclohexyle, phényle, naphtyle et tétrahydrofuranyle.

10. Procédé selon la revendication 1, dans lequel la concentration en accélérateur est dans une gamme de 0,01 à 20 pourcent en poids par rapport au poids du réactif insaturé.

11. Procédé selon la revendication 1, dans lequel le procédé est conduit à une température dans la plage de - 10°C à 220°C.